Bulletin 238 (Revised March 1934) June, 1932

Control of Diseases and Insect Pests of Potatoes in Up-State New York

M. F. Barrus and C. R. Crosby

Cornell Extension Bulletin

Published by the New York State College of Agriculture
at Cornell University, Ithaca, New York

L. R. Simons, Director of Extension Service

CONTENTS

CONTROL OF DISEASES AND INSECT PESTS OF POTATOES IN UP-STATE NEW YORK

M. F. Barrus and C. R. Crosby

The diseases and insect pests of the potato cause enormous losses every year. Such losses materially increase the cost of producing the crop. Potato growers who apply the control measures known to be effective will be able to produce a crop of better quality at a lower production cost per bushel than will those who do not. They will more often be able to produce the crop at a profit in low-price years and to make a greater profit during high-price years. In order to do this, however, it is necessary to execute a complete program of disease and insect control and to maintain the most favorable conditions for the growth of the plant.

This bulletin outlines those control measures known to be effective, and is prepared especially for potato growers in up-state New York. It does not attempt to supply advice regarding the control of either diseases or insects where such control is imperfectly known.

HEALTHY SEED

The first consideration in the control of potato diseases is the health of the seed tubers; that is, their comparative freedom from virus diseases, such as leaf roll, mosaic, spindle tuber, and yellow dwarf. If the seed is unhealthy, no amount of care in cultivation, fertilization, and spraying will insure a good crop. Time and money spent on these practices will then be largely wasted. If a grower's own seed is unhealthy, he should not plant it. Healthy seed will, for him, be cheap at any reasonable price if he intends to grow potatoes. On the other hand, the highest-priced seed is not necessarily the best.

It is impossible to determine from an examination of the tubers themselves whether they are healthy. Tubers so perfect in shape and conformity to type and so free from blemishes as to win the first place in exhibitions may yet be badly diseased and thus incapable of producing a profitable crop. On the other hand, small, irregular-shaped, scabby, pitted, and bruised tubers may be healthy and able to produce a profitable crop of excellent tubers. This does not imply that good-looking tubers are unhealthy and poor-looking ones are healthy nor that the latter should be sold as first-class seed; the authors merely wish to emphasize the impossibility of determining the health of the tuber from its appearance. To know whether seed tubers are healthy, one must know whether the vines

that produced them were healthy. A careful examination of the field one or more times during the growing season must be made by someone capable of recognizing those diseases that can be carried over in the seed before one can make any definite statement regarding the health of the tubers.

Of course, a potato stock that has produced high yields during a period of years may be assumed to have a satisfactory health record if it comes from the place where it has been produced during these years. If it is grown even for one year at some other place less favorably located for seed production, there can be no assurance that it will continue to produce well. Only an inspection of the vines during the growing season can determine whether such assurance can be given.

Since most potato growers find it impracticable to visit seed fields in order to select a satisfactory seed source, most of the Northern States and provinces have developed an official or a semi-official system of seed-potato certification. Under this system the growing plants are inspected by competent disinterested persons, and the product of suitable fields is authorized to be sold as certified seed. The table-stock-growers seed troubles can usually be solved most easily by the purchase of certified seed. Some growers will find it desirable to purchase their entire supply of seed, while others will find it satisfactory to buy only sufficient seed for a plot large enough to produce their seed for the following year.

THE SEED PLOT

It is desirable to locate the seed plot at some distance from potato fields in which virus diseases are likely to be prevalent. The seed plot may be by the side of other cultivated crops, such as corn, cabbage, or beans, provided the potato plants will be given the necessary applications of spray or dust to keep them healthy. It can be placed alongside the main field of potatoes if these are not badly affected with virus diseases. Long rows of seed-plot potatoes along the rows of the main field are undesirable because in such an arrangement a large proportion of the plants in the seed plot are exposed to infection. It is better to have the seed plot more nearly in a compact area.

The seed plot should be rogued at least once, and better twice, during the growing season. The first roguing should be made as soon as the plants are large enough to show leaf roll and mosaic, and anyway before the blossoming stage. The second roguing can be made three or four weeks later. The purpose of this is to prevent the spread of disease from affected to neighboring healthy plants. All plants showing leaf roll, mosaic, wilt, black leg, or other undesirable characters should be removed and carried from the field. Diseases can be detected easier on a cloudy

than on a sunny day. It is very much easier to detect these diseases in tuber-unit plantings than in ordinary plantings for, when the seed tuber is affected, all plants coming from it will be together rather than scattered throughout the field. In removing affected plants, especially at the first roguing, one should take also the old seed piece; otherwise it may send up new diseased sprouts which are as dangerous to the healthy plants as were the older vines. At the second roguing the new tubers, if they have attained seed size, should also be removed to prevent their becoming mixed with the healthy seed at harvest. A practical method is to put the diseased plants and tubers, upon removal, into a burlap sack, which is carried as one goes up and back across the field. Another sack is picked up for the second bout unless the first contains only a few plants. After the roguing is completed, the sacks of diseased potatoes are carted away for a distance of several rods or far enough so that the insects cannot get back into the seed plot. One can usually rogue two rows at a time and with practice can rogue four. If the seed plot adjoins the main field, it is advisable also to rogue about ten or twelve rows of the main field next to the plot, but the tubers from these should not be used as seed.

A seed plot should receive at least as good care as the main field. Fertilization, cultivation, and spraying should not be neglected. Seed produced in a seed plot that has been cared for as described should be relatively free from virus diseases and entirely satisfactory for planting the main field the following year. It should not, however, be used for the seed plot of that year unless it is known that the proportion of rogued plants was relatively small and that the roguing was done thoroughly. Even then, in localities where diseases spread readily, it is not safe to use such seed for next year's seed plot.

The diseases that greatly reduce the productive capacity of seed potatoes are those known as *virus diseases*. These include leaf roll, mosaic, spindle tuber, and possibly yellow dwarf. These are transmitted by the seed tuber but cannot be controlled by seed treatment nor by spraying. Leaf roll, mosaic, and spindle tuber may be transmitted from plant to plant aboveground by aphids, and spindle tuber has been shown to be transmitted also by means of grasshoppers and the cutting knife. The way in which yellow dwarf is transmitted aboveground is yet unknown. Plants infected with leaf roll, mosaic, or spindle tuber do not commonly show symptoms of the disease the year infection takes place but these symptoms do show in the progeny of such plants the following year and thereafter. Yellow-dwarf symptoms often show within a month after infection.

DISEASES CARRIED WITH THE SEED TUBER[1]

Leaf roll

Leaf roll causes dwarfed, rigid, yellowed, low-yielding plants, and an upward rolling of the margins of the lower leaves which are thicker and stiffer to the touch than is normal and the tips of which are lighter in color. Ordinarily, no evidence of the disease is found on the tuber, although a net-necrosis of the flesh of the tubers from recently affected plants has been observed. The tubers of leaf-roll plants are not infrequently produced on short stolons.

Mosaic

The term *mosaic* includes several distinct diseases, among which are mild mosaic, rugose mosaic, and leaf-rolling mosaic. These diseases are especially noticeable on the Green Mountain and Bliss Triumph groups of varieties. A mosaic is also very common in varieties of the Rural group but is often impossible to detect. The leaves of an affected plant ordinarily are crinkled, distorted, or mottled, depending on the kind of mosaic affecting them and on the temperature to which they have been subjected. The plants are smaller than healthy ones, except in mild cases, and the yield is reduced from 10 to 80 per cent.

Spindle tuber

The disease, spindle tuber, is occasionally observed in potato fields in this State. The affected plants are more erect than are healthy ones; the stems and flower stalks more slender; and the leaflets are smaller, somewhat twisted, and their margins wrinkled. The tubers may be long and cylindrical and may have more eyes than healthy tubers of the same size normally have. In varieties having colored tubers, the affected tubers are lighter in color than are healthy ones.

Yellow dwarf

Plants affected with yellow dwarf are much dwarfed, although plants becoming affected late in the season may be as large as healthy ones. The curled or roughened foliage is a chrome yellow before the stalk dies. Usually the stalks die early, beginning at the top. On the inside of the upper part of the living stalk and in the tubers are rusty-colored specks which make the disease easy to identify. Often the tubers are small, knobbed, and cracked, and borne tightly against the stem. The diseased hill is almost a complete loss. The disease seems to appear only after a period of high temperatures.

---

[1]For further information about these and other diseases of the potato, refer to Cornell Extension Bulletin 135, *Potato Diseases and Their Control.*

Other diseases

In addition to the virus diseases described, two other diseases, black leg and wilt, that occur occasionally in potato fields should be considered in roguing the seed plot. Plants affected with these diseases can usually be detected at the second roguing, and should be removed at that time if not earlier.

Black leg

Black leg, caused by the bacterium *Erwinia caratovora,* affects both the stalks and tubers. It may be detected in the field about blossoming time by the yellowish color of the foliage, by the erect stark appearance produced by the upward rolling of the leaflets, and especially by the blackened and rotted condition of the base of the stalk. In most cases only an occasional plant is affected, and this stands out clearly in contrast to the green foliage of its healthy neighbors. Tubers from affected plants may show dark areas at the stem end when this is cut away, and these may extend to a soft rotted condition farther within the tuber. Usually, affected tubers will show a black or brown or sometimes a straw-colored stem-end rot. During the progress of the disease, the flesh of the tuber becomes transformed to a soft, black, foul-smelling mass.

Wilt

Wilt, caused by the fungus *Fusarium oxysporum,* is a disease in which one or more stalks of a hill show a yellowing and drying of the leaves from the base upward until there is often only a cluster of green leaves at the top. On hot days this yellowing may be preceded or accompanied by a wilting of the leaves and even of the stalks. By peeling away the bark at the base of an affected stalk, one may observe a brown color of the woody part on one side or all the way around. Badly affected plants pull more easily than healthy ones even in the fall after the death of all plants. This is due to the rotted condition of the roots. Some or all of the tubers of affected plants may show a brown or black discoloration of the vessels when the stem end of the tuber is cut away. This condition, which may also be caused by other factors, is known as *stem-end browning.* The yield from wilted plants is usually less than from healthy plants because of the smaller size of the tubers.

SEED TREATMENT

Certain diseases of potatoes are caused by organisms that inhabit or are carried on the surface of the seed. These organisms can be killed by treating the potatoes in solutions or suspensions of mercury compounds. Such a treatment also protects the seed piece to some extent from decay after planting, and thus enables the sprouts to obtain more nearly the full

value of the food material contained in the seed piece than if it rotted early and to develop with less interference or interruption. It has been observed that treated seed on the average gives a better stand, or come-up, and a better yield than untreated tubers. These advantages do not always occur but may vary with location and with years. Mercury treatment aids in producing a cleaner crop, particularly as respects Rhizoctonia scurf. Seed treatment cannot be depended on to control common scab. However, since treating the seed aids in increasing the yield, it is a practice that can be used with profit by potato growers. To obtain the greatest benefits from such treatment, one should use good seed and should protect the vines during the summer by spraying or dusting them.

METHODS

Any one of several mercury compounds may be used for treating seed potatoes. Bichloride of mercury, or corrosive sublimate as it is more commonly known, has been employed for many years with satisfactory results. It is relatively cheap and easily obtained. It may be used in either a hot or a cold solution.

Hot corrosive sublimate

By the hot method the uncut seed tubers are immersed for two and one-half to four minutes in a solution of corrosive sublimate made by dissolving the material in water at the rate of 1 pound to 120 gallons and heating it to 124° to 126° F. From 1000 to 2000 bushels of seed potatoes can be treated in a day by this method. A wooden tank, holding from 8 to 10 crates when set side by side and about 500 gallons of solution, is used for this treatment. It should have a slatted false bottom which provides some space below the crates. This large body of solution prevents much fluctuation in the temperature when a crate of potatoes is put in. By this method two men are kept busy putting in and taking out the filled crates. Another man is needed to watch the temperature and to regulate it, to test the solution from time to time, and to dissolve and add the corrosive sublimate needed to keep the solution at the desired strength. Enough additional help will be needed to take away the treated potatoes and to bring a fresh supply as fast as they are treated. A head of about 80 pounds of steam is needed to maintain the temperature in a tank of this size when a relatively large boiler is used. The steam can be conducted into the tank by means of a rubber hose or by an iron pipe. A valve near the tank regulates the supply of steam. It will require about 1 pound of corrosive sublimate for each 80 to 100 bushels to be treated in the hot solution. Several farm bureaus of the State have maintained a treating service for several years, and the cost to members has varied from 3 to 6 cents for each bushel of seed treated. (Figure 1.)

FIGURE 1. TREATING POTATOES WITH HOT CORROSIVE SUBLIMATE AT FILLMORE, NEW YORK

When this method of treatment is employed, the treating should be done at least two weeks before planting, as the sprouts are killed by the treatment If two weeks intervene between treatment and planting, the sprouts will appear above-ground as promptly as untreated seed and more uniformly. This interval may well be utilized by placing the seed tubers where they will "green."

Cold corrosive sublimate

For most growers to whom the treating service described in the preceding paragraphs is not available, the cold method is applicable. For the average farmer, ordinary 50-gallon barrels are the most accessible containers for holding the tubers during treatment. These should be reasonably clean. Oil barrels may be employed if scrubbed clean with soap and water. Planks are laid across two blocks of wood to make a platform as high as a pail. As many barrels as are needed, depending upon the quantity of potatoes to be treated and the number of men working, are set in a row upon this platform (figure 2). One barrel in which to mix the solution is left standing on the ground. A hole an inch in diameter is bored in the side near the bottom of each barrel on the platform for the removal of the solution after the seed treatment. These barrels, together with two pails, preferably wooden or enameled ware, and a wooden paddle are the apparatus needed for treating the seed.

Some growers prefer a wooden trough large enough to accommodate 8 to 10 crates set side by side and high enough so that the solution will cover the tubers when the crates are filled. Other devices have also been

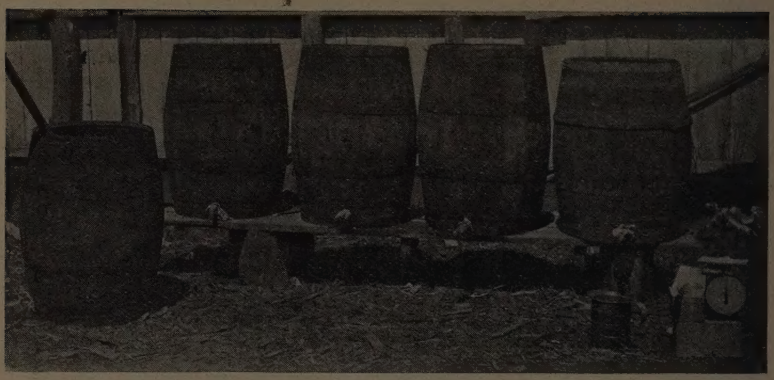

FIGURE 2. A SIMPLE AND CONVENIENT OUTFIT FOR TREATING SEED TUBERS WITH COLD CORROSIVE SUBLIMATE

used. Each person should work out for himself the kind of apparatus most convenient and available under his conditions.

Metal containers and burlap or other bags should not be employed in soaking the seed, as corrosive sublimate reacts with these substances and becomes weakened by contact with them. Dirt also weakens the solution; thus, it is advisable to clean the containers before using them, and, if the tubers are covered with soil, to wash them before treating.

A suitable place for the apparatus should be selected, having in mind the location of the storage, the water supply, and the place where the tubers will be kept after treatment. As seed treatment is sloppy work, some place out of doors is desirable, unless the treatment is made on rainy or frosty days.

The amount of corrosive sublimate required to treat a given quantity of potatoes will vary with the number of tubers to be treated, the nature of the containers, and the amount of dirt on the tubers or in the containers. One hundred bushels can be treated with from 1 to 2 pounds. Thirty gallons of a standard solution (1–1000) requires four ounces of corrosive sublimate. If desired, the material may be bought in four-ounce packages. The powder is dissolved in about a gallon of hot water in an earthen, glass, or wooden container. The hot solution is then added to the 29 gallons of cold water in the barrel on the ground, and the mixture is stirred with a paddle. Very cold water should not be used, as the corrosive sublimate is not active at low temperatures.

The first barrel on the raised platform should be nearly filled with potatoes. The solution is poured over them until the tubers at the top are covered an inch or more with the liquid. They are left in the solution for

one and one-half hours. The exact time that the solution should be drawn off should be marked with a pencil on the barrel. An alarm clock has proved to be a good reminder. While the first barrel of tubers is being treated, the other barrels may be filled and more solution made to cover their contents. When the tubers have remained in the solution the sufficient length of time, the plug is removed and the solution is caught in a pail as it comes out and is dumped into the barrel on the ground. Two men with pails can easily take care of this. The last pailful of this solution may be discarded if it is very dirty. The barrel is then tipped over, the potatoes are dumped on the ground or floor, and the barrel is put back in place and again filled with untreated potatoes. Each successive barrel is emptied after the proper lapse of time. With from 6 to 8 barrels in use, two or three men will be kept busy making the treatments. From 200 to 300 bushels can be treated in a day if the location of the treating apparatus, the water supply, and the storage are convenient.

Corrosive-sublimate solution weakens with use. After it has been used three or four times it becomes one-half, or less, as strong as when freshly made. Because of this, it is customary to discard it after the third use. The addition of ¾ of an ounce of sublimate to each barrel of solution after each use has been advised so that the solution may be used four or five times. If this is done, it should not be used more times than this, for the strength of the solution is then unknown. A way to enable one to use the solution many times is to test it with potassium-iodide solution after each use and by this test to determine the additional amount of corrosive sublimate needed to bring it up to the required strength. By this method the solution need not be discarded until it becomes very roily. Directions for making the test may be obtained from county agricultural agents.

After the seed tubers have been treated, they should be placed where they will dry. The cold-corrosive-sublimate treatment, like that of the hot solution, should be made at least two weeks in advance of planting. The interval between may be used for greening the tubers.

Yellow oxide of mercury used as an instantaneous dip

Yellow oxide of mercury was first used for treating potatoes by Doctor F. M. Blodgett, of the Cornell University Agricultural Experiment Station, in 1929, and experiments have been conducted with it each year since. It has proved to be the best material for the instantaneous-dip method of those thus far tried and is as effective as corrosive sublimate, in the control of Rhizoctonia sprout rot and tuber decay.

Apparently no injury to the tubers results when they are treated at any time previous to planting. The treatment of cut seed with yellow oxide is not recommended at the present time. During 1932 more than 100,000

bushels of seed potatoes are known to have been treated with this material with satisfactory results.

To make the treatment, it is necessary only to dip the seed tubers into a suspension of yellow oxide in water so as to insure that the surface of all of them becomes covered with the mixture, then to take them out and allow them to drain and the surface to dry. The treatment can be made in a treating machine or one can construct a cheap and simple apparatus that will answer the purpose very well (figure 3).

FIGURE 3. HOMEMADE APPARATUS FOR TREATING SEED POTATOES BY THE INSTANTANEOUS-DIP METHOD
Metal parts have been coated with asphaltum paint

A half barrel or other wooden container of about the same shape is desirable for holding the treating mixture. A metal container may be used if painted on the inside with a good coating of asphaltum paint. It is also useful to have another similar tub or pail for making additional mixture and a wooden paddle for stirring the mixture.

Two or more woven-wire (½-inch mesh), flat-bottom baskets with handles should be purchased or constructed which, when set inside the tub, will nearly fill it. This basket should be painted inside and out with an asphaltum paint. A drainboard should be constructed long enough to hold two or more baskets and so located that, when the baskets of treated potatoes are placed on it, the liquid draining from the potatoes will run back into the tub, to prevent waste.

Procedure

One pound of yellow oxide of mercury (technical grade) is added to 15 gallons of water in the tub, and this mixture is stirred vigorously with a wooden ladle until all is in suspension. A basket is filled with seed potatoes, and is then dipped into the liquid, is plunged up and down two or three times, and is turned sidewise at the same time to insure complete wetting of the pieces and to keep the mixture well stirred. The basket of treated potatoes is removed to the drainboard, the mixture in the tub is stirred, another basket is filled, and the operation is repeated. When several baskets are used, they can be left on the drainboard longer and there will be less waste of material than when only two baskets are used. After draining, the potatoes are dumped into a crate where they will dry.

Additional mixture may be made up in the extra tub or pail and may be added to the treating tub as needed. It is very essential that the mixture be thoroughly stirred before it is poured into the treating tub as otherwise it will be weak. The yellow oxide is heavy and settles quickly. The mixture does not lose strength and can be used as long as any is left. Fifteen gallons will usually treat 100 or more bushels of seed potatoes. The treatment costs less than 2 cents a bushel for material.

Precautions

Seed potatoes treated with any of the above-named mercury compounds are poisonous and should not be eaten by man nor animals.

Formaldehyde

There is some evidence that formaldehyde is somewhat more effective than mercury compounds for the control of potato scab in the limestone sections of the State. This does not signify that mercury compounds do not kill the scab organism on the surface of the seed nor does it mean that treatment with formaldehyde will control scab if conditions of the soil are favorable for its development. Moreover, formaldehyde has, in this State, been less effective than mercury compounds in destroying Rhizoctonia on the surface of the seed tuber. For those growers who wish to use formaldehyde in treating their seed potatoes, the following procedure for making the cold treatment is given:

One pint of commercial formaldehyde is diluted in 30 gallons of water. The potatoes are immersed in this solution for 1½ to 2 hours, and are then removed, drained, and allowed to dry. The same apparatus may be used in making the treatment as is used for the cold-corrosive-sublimate treatment, except that metal containers may be used if desired. The formaldehyde solution does not lose strength, so it may be used over and over again. Seed potatoes treated with formaldehyde are not rendered poisonous by the treatment.

Hot formaldehyde

The hot formaldehyde treatment is similar in operation to that of the hot corrosive sublimate. Either metal or wooden tanks may be used in making the treatment. One gallon of 40-per-cent formaldehyde (formalin) is diluted with 120 gallons of water, making a solution twice as strong as that used in the cold treatment. This is heated to a temperature of 124 to 126° F. and is held within these limits by steam or by means of a fire maintained beneath the tank. A false bottom to the tank is necessary to keep the tubers at the bottom from becoming overheated. The potatoes in crates or wire baskets are immersed in the hot solution for three minutes. Solution lost in the process of treatment should be replaced from time to time from a reserve supply. The solution does not become weaker by evaporation or by continued use but, to allow for condensation water when live steam is used for heating, 0.9 pint of formaldehyde should be added after every 50 bushels of tubers are treated. When steam is used for heating, a coil is preferable to live steam as then there will be no loss in strength of solution. After immersion the potatoes are placed together and covered with bags, blankets, or canvas for an hour to hold the formaldehyde fumes around them. Then the covering is removed and the potatoes are permitted to dry.

DISEASES CONTROLLED BY SEED TREATMENT

Rhizoctonosis

(Caused by the fungus *Corticium vagum* var. *solani* (*Rhizoctonia solani*)

Rhizoctonosis affects the tubers, sprouts, and the mature plant. On the tuber, the fungus ordinarily shows as small brown-black bodies closely adhering to the skin but not penetrating it. They may be as small as a pinhead or as large as a half-pea. They may be few in number or the surface may be dotted with them. They are most easily seen when the tuber is washed, for they are almost coal-black when wet. These are the resting bodies (sclerotia) of the fungus and do no harm to the tuber beyond marring its appearance. The fungus may also develop brown threads, or strands, over the surface of the tuber or a portion of it, causing a russet appearance of the skin. The pitting of the tuber, once thought to be due to Rhizoctonia, is now believed to be initiated by wire worms, although the fungus may be found in the pits.

Rhizoctonia also produces cankers on the tender young sprouts before they have appeared aboveground. These often surround the sprout and rot it off. This condition is known as *sprout rot* or *sprout canker*. When such a condition occurs, new sprouts are sent up, but these also may become affected. The final result is the failure of these sprouts to appear or their

development into weak vines. When not so badly affected, the vines, although appearing late, may yet develop into a productive plant. The sprouts are attacked and rotted in this way by a fine white fungous growth proceeding from the black bodies on the seed tubers. As this fungus is also capable of living in the soil for a long time, the attack of the sprouts may come from the fungus in the soil as well as from the tuber, but experiments indicate that it comes largely from the sclerotia on the seed piece. This explains why seed treatment reduces the amount of sprout rot.

The fungus attacks also the base of older vines which may result in an abnormal appearance, such as the development of aerial tubers in the axils of the leaves, enlarged and purplish stalks, and the production of many small irregularly-shaped tubers at the surface of the soil.

Control consists in treating the seed with a mercury compound, greening the seed so as to promote the early appearance of sprouts, and, in planting, to provide for a shallow covering at first.

Black leg

See page 7 for a description of this disease.

Scab

(Caused by *Actinomyces scabies* and other species of Actinomyces)

Scab is caused by certain minute fungi which attack the skin of the potato tuber, causing roughened areas of various sizes. These areas may be few in number or so numerous as to cover the entire surface of the tuber. The scabbed areas in late-dug potatoes may become entirely eaten away by millipedes so that the original scab cannot be seen. The scab organism is carried through the winter in the soil, in manure, and in the scab spots of the tubers. The growth of the organism is favored by hot dry soil and by an alkaline condition of the soil. It is believed that infection occurs most readily when the tubers are young, provided soil conditions are favorable at that time.

Seed treatment by any of the methods already described is believed to destroy the organism on the surface of the seed tuber. However, even when treated seed or clean seed is planted, scab may develop extensively on the new crop if the soil is alkaline in reaction and the organism is present.

To control the disease, either treated or clean seed should be planted in soil known to be free from the scab organism or in soil sufficiently acid (not more than pH 5.4) to prevent the development of the organism. Soils already acid should produce potatoes relatively free from scab. Soils not very alkaline can be changed to an acid condition by proper management. This includes abundant use of cover crops, the use of acid-producing fertil-

izers, such as ammonium sulfate for the nitrogen requirement, and the application of sulfur to the soil before planting. Cover crops probably have some effect in reducing scab in other ways than through any change in the soil reaction resulting from their use. Sulfur should be used only when necessary and, then, be applied only to the parts of the field where scab has been troublesome in the past. Finely ground sulfur, such as dusting sulfur or inoculated sulfur, is most satisfactory, although a somewhat coarser sulfur may be more economical to use and is easier to apply. It should be applied broadcast after the ground is plowed, and should be harrowed in before the potatoes are planted. The amount required will vary from 200 to 600 pounds an acre, depending on the degree of alkalinity of the soil or on the extent to which the previous crop was scabby. If ammonium sulfate is to be used in the fertilizer, the amount of sulfur may be reduced by one-third or one-half, and, if scab was only slightly troublesome, it can be omitted altogether. Sulfur has not been effective in controlling scab under all conditions, particularly in the heavy types of soil.

Potatoes, while they will tolerate an acid condition sufficient to control scab, will, nevertheless, be adversely affected if the soil acidity is much increased, as will happen if either ammonium sulfate or sulfur is applied year after year. Even a single application will have a residual effect, so that care should be exercised, especially when sulfur is used, to make the application only sufficiently heavy to bring about the desired result. Some other crops, such as legumes, cabbage, and corn, are likely to do poorly following heavy applications of sulfur. Potato growers who have trouble with scab could well afford to have their soil tested from time to time to determine the degree of change needed to make the soil unfavorable for scab development.

If potatoes are to be grown in alkaline soils, there is evidence to indicate that long rotations should be practiced and that heavy green cover crops should be plowed under previous to using the field for potatoes. Since an alkaline soil condition is favorable for scab development, it is obvious that applications of alkaline-producing substances, such as lime and wood ashes, to a soil that is already alkaline should be avoided. Even nitrate of soda should not be used repeatedly under such conditions. Although all precautions be taken to avoid scab, it will sometimes be troublesome, especially when hot dry soil conditions prevail during the formation and early growth of the tubers.

SPRAYING AND DUSTING

Applications of fungicides and insecticides to the potato vines during the growing season will protect the vines to a large extent from diseases and insects and will enable them to produce a larger crop of tubers free from

rot than when the vines are not thus protected. Many experiments have shown beyond any question the value of such applications. It is important, however, that the right kind of materials be used and that they be properly applied if profitable results are to be obtained. Moreover, if the seed is weak and the stand poor, and if the soil is poorly adapted to potatoes, infertile, poorly prepared, or poorly cultivated, neither spraying nor dusting is likely to be profitable or even worth while. Applications of fungicides and insecticides are likely to be valuable when other good practices are faithfully followed.

SPRAYING POTATOES

For many years 5–5–50 bordeaux mixture (5 pounds of copper sulfate, 5 pounds of lime, and 50 gallons of water) has been used as a spray throughout the season. Recent experiments have indicated, however, that this formula can be modified to advantage by reducing the lime content one-half and by changing the concentration of the mixture at the various applications. The most effective results in increasing yields and in improving quality have been obtained on Rural potatoes by supplying from 70 to 80 pounds of copper sulfate per acre in the form of bordeaux mixture during the season and by applying the greater part of this during the first half of the growing period. This heavy application of copper sulfate has a stimulative effect on the vines which is most desirable early in the season. To make such application, the schedule should be about as follows:

Application	Time	Formula			Purpose
		Copper	Lime	water	
First	When plants are 4 to 6 inches high	10	5	100	Flea-beetles Stimulation
		4 pounds of calcium arsenate			Colorado potato beetle
Second	7 to 9 days later	20	10	100	Flea-beetles Stimulation
Third	7 to 10 days later	16	8	100	Flea-beetles Stimulation
Fourth	10 days later	12	6	100	Leaf hoppers Stimulation
Fifth	10 days later	8	4	100	Leaf hoppers
Sixth	12 days later	6	3	100	Leaf hoppers Late blight
Seventh	14 days later	4	2	100	Leaf hoppers Late blight
Eighth	10 days later	2	1	100	Leaf hoppers Late blight
Total for season		78	39		

This schedule requires a total for the season of 78 pounds of copper sulfate and 39 pounds of calcium hydrated lime per acre when 100 gallons of mixture is applied to an acre at each application. A lower-strength bordeaux at the first rather than at the second application is used to build up resistance to copper injury which may occur if the higher strength is used at first. Those farmers who do not prefer to use such a schedule, may use the 5–2½–50 (10–5–100) formula, eight applications of which will provide a total of 80 pounds of copper sulfate and 40 pounds of hydrated lime per acre. The applications should be timed the same as those given in the schedule.

Making bordeaux mixture

The first step in making bordeaux mixture is to prepare stock solutions of copper sulfate and of lime. The copper sulfate may be used either in granulated form or as large crystals, but it should be free from foreign matter. A calcium lime that has not become air-slaked is desirable whether lump or hydrated lime is employed. If hydrated lime is used, a form which is extremely fine, is most satisfactory. If magnesium lime (finishing lime) is used, the amount of lime by weight should equal the amount of copper sulfate, regardless of the formula.

Stock copper sulfate

A clean burlap bag containing 40 or more pounds of copper sulfate is suspended in a wooden barrel containing an equal number of gallons of water (40 or more) so that the sulfate is immersed at the surface of the water. The sulfate will dissolve in a few hours or overnight.

Stock lime

If lump lime is used, the solution is prepared by slaking 40 pounds of the lime in a barrel. Sufficient water is added, little by little, to prevent the lime from becoming dry but not enough to drown it. After slaking is apparently over, the lime should be allowed to stand for an hour or more, but not allowed to dry, to permit the small particles to become completely slaked. Then enough water is added to make 40 gallons of milk of lime.

If hydrated lime is used, the solution is prepared by placing 40 pounds of the lime in a barrel and adding 40 gallons of water, stirring the mixture thoroughly. The hydrated lime should stand for 24 hours or more in the water. Bordeaux mixture made by adding hydrated lime directly to the screen on the tank and washing it through contains coarser particles that may clog nozzles than that prepared before it is put into the tank.

Mixing the materials

To make bordeaux mixture, a 100-gallon sprayer tank is filled about three-fourths full of water. Then as many gallons of stock copper-sulfate

solution are poured into the tank as pounds of copper sulfate are needed for that particular spray, and half as many gallons of stock milk of lime, previously stirred, are added. For example: if a 20–10–100 mixture is desired, 20 gallons of stock copper sulfate and 10 gallons of stock lime are needed; if an 8–4–100 is desired, 8 gallons of stock copper sulfate and 4 gallons of stock lime. The mixture is stirred or agitated. The tank is filled with water. All materials are run into the tank through a W- or cone-shaped bronze or copper strainer with eighteen or more meshes to the inch.

Poison

Four pounds of calcium arsenate to each 100 gallons of spray may be added when bugs are troublesome, usually at the first or at the first and the second application.

Another method of preparing bordeaux mixture

This handy method used by many Long Island farmers is applicable where running water is available. The materials are dissolved in a small wooden tank divided into two compartments. The proper amount of copper sulfate is placed in the bottom of one compartment and the lime in the other. The compartment for the copper sulfate may be lined with copper sheeting and for the lime with tin or zinc, if desired. A stream of water flows into the bottom of each compartment through a pipe which for the copper-sulfate compartment, should be of copper or be a rubber hose. As the water rises, the chemicals are dissolved. The overflow is conducted from the top of each compartment through a screened outlet into a common mixing trough and thence into the sprayer tank (figure 4). Before the tank is filled, all of the copper sulfate and all of the lime will have been dissolved or washed through.

In place of this dissolving tank, two barrels may be used. Screened containers for holding the chemicals (the one for the copper sulfate should be of copper) should be suspended from the top of the barrel and should be deep enough to reach nearly to the bottom. A screened outlet is cut in the side of each barrel near the top through which the solution is conducted to a mixing trough.

To make 500 gallons of a 10–5–100 bordeaux mixture by this method, 50 pounds of copper sulfate is placed into one container and 25 pounds of hydrated lime into the other. About 250 gallons of water may pass through each container, but it is immaterial whether the same amount passes through each so long as enough passes through to dissolve the materials.

Calculation of amounts of materials needed

It has already been stated that from 70 to 80 pounds of copper sulfate per acre is required for best results on Rural potatoes and this quantity is best

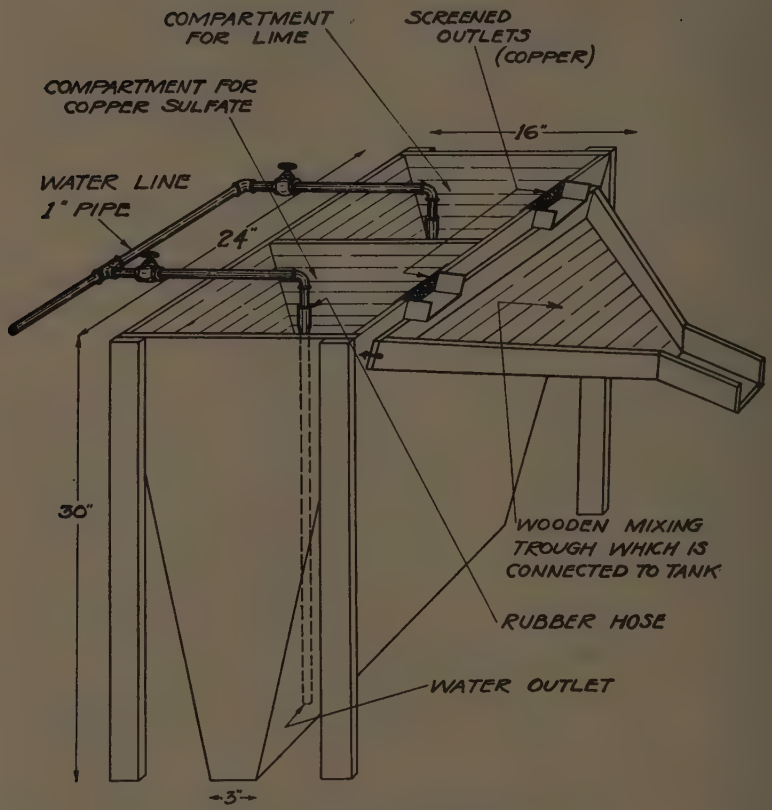

FIGURE 4. AN APPARATUS FOR MAKING BORDEAUX MIXTURE RAPIDLY WHEN RUNNING WATER IS AVAILABLE

for other late varieties and for Green Mountains. Early varieties may not need so much. One-half as much lime by weight, as of copper sulfate is needed. Four pounds of calcium arsenate per acre is needed for one application. Only rarely will a second application of the poison be necessary. The total requirement can then be determined by multiplying these figures by the number of acres to be grown. If a man has 10 acres of late potatoes, he will need about 800 pounds of copper sulfate, 400 pounds of hydrated lime, and 40 (or 80) pounds of calcium arsenate. These materials should be purchased in advance of the spraying season and should be kept stored where they will not spoil.

Applying the spray

As has been indicated, potatoes should be sprayed every ten days or two weeks during the summer in order to keep the vines protected against insects and blight. The first application should be made when the plants are well out of the ground and be followed by others seven to ten days apart until three of four have been made. These early applications benefit the plants by destroying the potato beetle, by repelling the flea beetle, and by stimulating the growth of the vines. Applications in the later part of the season may be made at intervals of twelve to fourteen days to prevent hopper burn unless late blight is present in the field, in which case more frequent applications will be needed. The applications should ordinarily be continued until the vines are approaching death or until a killing frost is expected.

It is much more important that the bordeaux mixture be applied thoroughly at each application than that any particular formula or a particular time schedule be used. If the grower wishes to obtain the benefit from spraying, he must see to it that the full amount of spray material is applied at each application and that it is well enough distributed each time so that all parts of the vine receive a protective coating. If he will do this, he may be sure of being well repaid by the operation.

The applications should be made with the sturdy sprayer equipped with three nozzles to a row and maintaining a pressure of at least 250 pounds to the square inch. This is needed in order to do a thorough job. The nozzles should be adjusted so that the spray strikes the vines with some force and so that there is not much overlapping at the margins of the cones of spray until after the spray has reached the vines (figure 5). They should also be adjusted so that all parts of the vines are covered by the spray mixture. Readjustments will be needed from time to time as the vines increase in height and width and when the boom gets out of adjustment. As nozzle disks become worn by the force of the spray so that they are not so effective in forming a satisfactory mist, they should be replaced with new disks. This will ordinarily be needed after each 65 to 75 acres sprayed.

Selection and care of a spraying machine

The first consideration in spraying is a durable machine for applying the spray properly. Several excellent spraying machines are on the market, any one of which will ordinarily give satisfaction. In selecting a machine a grower should consider several factors, among which are the following: size and durability of machine to buy; availability of repair parts; capacity of the machine; ease of adjustment of parts and accessibility to the various parts needing care, adjustment, and repair.

PHOTOGRAPH BY E. O. MADER

FIGURE 5. SPRAYING POTATOES WITH A POWER SPRAYER AT PITTSFORD, NEW YORK

Note the arrangement of the nozzles and the direction of the cones of spray

The size of machine to buy will depend upon the acreage of potatoes to be sprayed and to some extent upon the lay of the land. It is not wise to purchase a light machine. A rugged traction machine capable of applying 125 gallons of spray to the acre at a pressure of 250 pounds to the square inch is the minimum requirement that should be considered. This will prove satisfactory for growers having from 5 to 20 acres of potatoes. Growers having less than 5 acres should consider joining a spray ring or should use a hand duster. Growers of more than 20 acres may profitably use a power sprayer.

The machine should be rugged. The wheels and axle, especially, should be heavily built. Unless it is well built throughout, there will be more or less danger of breakage during the season, and this usually occurs when one wants to continue spraying. It is better not to economize on the price of a machine at the expense of good construction.

No matter how excellent a machine may be, it is useless when out of commission. One should be able to obtain a replacement for a broken or

wornout part either from the dealer from whom the machine was purchased or from the manufacturer within 24 or 48 hours at the most.

The capacity of the machine should be suffiicient to maintain easily a pressure of 250 pounds to the square inch with the number of nozzles one wishes to use.

Ease of adjustment of parts and accessibility to the various parts needing care, adjustment, and repair are important. Any special tools required should be of good quality.

The boom should be constructed to carry three nozzles to a row and be adjustable in a vertical direction so that it can be raised and lowered easily. One should also be able to adjust the nozzles in any direction.

The strainer on the tank should be cone-shaped or W-shaped and not flat, for the flat strainers clog much more easily. A sediment strainer should be fitted to the pipe between the tank-outlet and the pump. This will save much delay caused by clogged nozzles and will also aid in preventing the scoring of cylinders.

The machine should be constructed so as to be well-balanced when the driver is seated, in order to prevent a drag on the horses' necks. Usually the tank is evenly balanced over the axle

A vine-lifting attachment to prevent wheels from injuring vines is usually desirable. If the machine is not thus equipped by the manufacturer, a homemade vine-lifter can be constructed with one type of hay-rake teeth. Injury to the vines and roots can also be lessened by padding the wheel rims of the spraying machine with old automobile tires (figure 6).

The machine should be adequately lubricated throughout whenever used. The axle bearings may need attention several times during a day's spraying.

After each day's use, the nozzles should be removed and washed in water. Water should be added to the tank and pumped through the machine to flush out the pipes.

At the close of the spraying season, the tank should be cleaned of sediment, the pump and pipes flushed clean, and a light oil (filtered crank-case oil will do) pumped through the machine. The boom should be taken apart and the pipes and nozzles stored in oil. The machine should be housed to protect it from weathering. A spraying machine properly cared for will give returns in efficiency of operation, while a poorly-cared-for sprayer is often worthless.

DUSTING POTATOES

Many growers prefer to apply copper lime dust to their potatoes rather than to use bordeaux mixture as a spray. Dust is practicable if properly applied and may be used in the place of spray in potato fields. When such a dust comes in contact with water, the materials in the mixture go into solution and form bordeaux mixture, so that the material finally left on a

FIGURE 6. THE WHEEL RIMS OF THE SPRAYER ARE COVERED WITH OLD AUTOMOBILE TIRES

If the wheel rims are covered with old automobile tires, less injury is done to the vines and roots of the plant

dusted leaf is the same as that left by spraying it. If good results are to be obtained, it is necessary that dust be applied frequently and in sufficient amounts and that the application be uniformly and thoroughly made. It will not pay to dust a field that has a poor stand or is making a poor growth any more than it will pay to spray such a field. On the other hand, dust will give considerable protection against insects and blights, and will be profitable when applied to a field that is capable of producing a good yield.

Copper-lime dust

Copper-lime dust may be purchased ready-mixed or the ingredients may be obtained separately and mixed at home. The usual recommendation is to use a mixture of 20 per cent of monohydrated copper sulfate with 80 per

cent of lime. When a poison is needed, 20 pounds of calcium arsenate is substituted for an equal quantity of hydrated lime in the mixture.

Formula

For making this mixture, also known as 20–20–60 copper-arsenate-lime dust, one would use 20 pounds of monohydrated copper sulfate, 20 pounds of calcium arsenate, and 60 pounds of hydrated lime. As hydrated lime is commonly put up in 50-pound sacks, it is more convenient to dump a sack of lime into the mixer and then enough of the other materials to make the right proportion. When this method is followed, one uses 50 pounds of hydrated lime with 17 pounds of monohydrated copper sulfate and 17 pounds of calcium arsenate. If a poison is not needed, one uses 50 pounds of the lime with 12½ pounds of monohydrated copper sulfate.

Mixing the dust

A dust mixer should be purchased or made at home out of a tight barrel or steel drum. After the correct amount of each material has been placed in the container, the mixer should be turned for three or four minutes at the rate of 20 to 30 revolutions a minute. It is important that the ingredients be thoroughly mixed. The mixing should be done where there is a good circulation of air. It is advisable for the operator to moisten a piece of cheesecloth and to tie it over his nose and mouth to breathe through, or to use a respirator.

Mixed material, if kept for a time, should be stored in a clean, dry, tight can, and the cover kept on tight. The can containing monohydrated copper sulfate should always be kept tightly covered, except when taking the material out. The sacks containing hydrated lime should be kept tight and dry. Year-old lime or lime left exposed to the air for a considerable time should not be used. The lime used should be a hydrated lime not excessively fine. The use of magnesium hydrated lime (finishing lime) has given satisfactory returns. The monohydrated copper sulfate should be dry, finely pulverized, free from lumps, and should have a white color with a faint bluish tint. When it has a gray, a drab, or a brownish color, it is not satisfactory.

Applying the dust

The first application should be made as soon as the plants are well up, and others at intervals of ten to fourteen days until a killing frost is expected. Applications should be made when the vines are wet and when the air is quiet. The night or early morning usually provides these conditions, although the latter time is preferable because the bordeaux mixture formed on the wet leaves soon dries and adheres to the surface. An examination of the vines should be made before dusting is started to determine whether

they are wet enough. Copper-lime dust should not be applied when the foliage is dry, as it is not effective and is therefore wasted.

The dust machine should apply dust uniformly over the plants and envelop them in a cloud. Two nozzles to a row are necessary and three are better. A power machine gives better distribution than a traction machine. For small areas, a fan type of hand duster is satisfactory by going over each row twice, especially when the vines are large. When using a hand-duster, the operator should wear high-topped boots to protect his legs from the copper dust.

It will require 37½ pounds of the 20-per-cent dust to be equivalent in copper sulfate to 100 gallons of 5–5–50 bordeaux mixture. As 100 gallons of bordeaux are needed at each application to each acre of potatoes when the vines are large, at the least this quantity of dust will be needed to give equal protection. When bugs are troublesome, 20 pounds of calcium arsenate should be substituted for an equal amount of the lime. The poison may not be needed after the bugs have disappeared.

DISEASES AND INSECTS CONTROLLED BY SPRAYING AND DUSTING

Late blight

(Caused by the fungus *Phytophthora infestans*)

Late blight is one of the most dreaded potato diseases because it can cause extensive losses in a short period of time. During hot dry seasons it rarely appears, but in wet seasons it may become very prevalent. On Long Island it may appear as early as June, but in up-state New York it rarely shows until late July or August when the nights are cool.

Late blight shows on the leaves as dark water-soaked areas which rapidly enlarge, often involving the entire leaf in one to four days. A white mildew appears over the diseased area on the underside of the leaf, and it is by this that the disease can be positively identified. This is especially prominent when the air is very moist.

On the tubers the disease appears as irregular discolored areas that later become somewhat sunken. Within the flesh of the potato, a reddish brown dry rot is produced which, in the initial stage, does not extend inward beyond the straw-colored ring of conducting vessels. The diseased tissue is often invaded later by bacteria which bring about a foul-smelling soft rot.

The causal fungus overwinters in the affected tubers. If these are planted, the resulting plant is often attacked by way of the seed piece. The fungus finds its way to the surface of the ground through the diseased sprout, on which it fruits, producing spores in abundance. From this source of infection, spores are blown by the wind to neighboring plants and fields where they bring about the blight.

Late blight occurs during wet weather, especially when the night temperature drops to 50° F. or lower and the days are warm. Spore production, dissemination, and germination take place only under moist conditions. In years when there is abundant moisture in the form of rain, fog, or heavy dews, particularly in the latter part of the season, the disease becomes epidemic.

Control

The vines should be sprayed thoroughly with bordeaux mixture or dusted with copper-lime dust as indicated in the preceding pages. The first application should usually be made when it is necessary to apply poison for the potato beetle. The insecticide can be added directly to the spray or dust mixture. Applications should be made often enough to cover and to protect the new growth, which will ordinarily be about every two weeks. When there is danger from blight, they should be made more frequently. Applications made before rainy periods are more effective than when made after them. Three nozzles are needed to a row, especially during the later applications, in order to do a thorough job. At least 100 gallons of the spray mixture or 35 pounds of the dust mixture are needed to an acre when the vines are large. Applications should be continued late in the season. The horses and wheels will not injure the vines as much as will late blight. Wheel injury can be materially reduced by the use of vine spreaders and by covering the rim of the wheel with discarded casings of automobile tires (figure 6).

Although thorough applications of a fungicide will control late blight, it is also well to avoid planting tubers showing any rot. Potatoes from blighted fields should not be dug until the vines are dead and dry. If the vines are badly blighted and there is evident danger of tuber rot before frost, the vines may be killed by spraying them with a copper-sulfate solution made by dissolving 15 pounds in 100 gallons of water. Potatoes from affected fields should be stored in a moderately warm place for a week or two in order to enable one to sort out the rotted ones. The balance should then be stored in a cool place. The nearer the temperature is to 37° F. the better they will keep.

Early blight

(Caused by the fungus *Alternaria solani*)

Early blight is principally a disease of the leaves, occasionally affecting the stalks and tubers. By destroying the leaf tissue, the disease causes a reduction in yield of tubers. On the leaves, it occurs as dark brown or black, oval or angular spots which may show a series of concentric ridges that give them a target-board effect. At first the spots are small but after the leaf is weakened or dead, or even before, the spots may enlarge to a

diameter as great as ½ inch. These areas may appear first on the older, lower, and less vigorous leaves, and may be so numerous as to cause the leaf to die. The leaves above may become similarly affected until finally only a few green spotted leaves at the top of the plant remain. Spots may likewise develop on the leaf stems and on the upper parts of the stalks.

Early blight is caused by a fungus which produces large, dark-colored spores on either the lower or upper surface of the affected areas. These spores are capable of remaining alive over winter. The fungus mycelium also can pass the winter in old affected vines and produce a crop of spores the following spring.

The spores are disseminated mainly by the wind. A relatively high temperature with abundant dews or rainy weather and weakened plants bring about a condition most favorable for the production of spores and for infection. Epidemics of early blight may occur when late blight is absent, but the disease is not nearly so important.

Control

Early blight is not so easily controlled as is late blight, but frequent applications of bordeaux mixture, beginning when the plants are young and continuing at ten-day intervals throughout the growing period, will often hold the disease in check and sometimes control it entirely.

Colorado potato beetle

(*Leptinotarsa decemlineata* Say)

The adult Colorado potato beetle passes the winter in the ground, usually several inches from the surface. The beetles emerge from their winter quarters just before early-planted potatoes come up and are ready to attack the plants as soon as they appear aboveground. After feeding on the potato foliage for a few days the female beetle begins to deposit her orange-colored eggs on end in masses on the underside of a leaf. The eggs are not all laid at one time but in successive batches. The egg-laying period for each female is from four to six weeks. The eggs hatch in from four to nine days and the young larvae, or slugs, begin at once to feed on the foliage. The larva becomes full-grown in ten days to three weeks and then enters the ground for pupation. After a pupal period of five to ten days, the adult emerges and soon begins to lay eggs for a second brood of slugs. Fortunately, the second brood is usually not so destructive as the first; the beetles are not so abundant and the plants being larger are more able to withstand attack.

Control

In up-state New York the Colorado potato beetle can be controlled by using 4 pounds of calcium arsenate in 100 gallons of bordeaux mixture for

the first one or two applications of the regular spray schedule. To obtain the best results, the poison should be applied at least as soon as the first-laid eggs begin to hatch. About 100 gallons of the spray material should be applied per acre, using sufficient pressure and the proper arrangement of nozzles to thoroughly cover the plants. It should be remembered, however, that increasing the amount of poison in the mixture will only in part make up for using too small a quantity of spray material per acre or for faulty methods of spraying.

Early spraying is essential for beetle control because the newly-hatched slugs are more easily poisoned than are the larger ones and they are destroyed before much damage is done. Many failures to control the beetles are the result of waiting too long before applying the poison.

If a dusting schedule is followed, the mixture should contain 20 per cent of calcium arsenate for beetle control.

Potato flea-beetle

(*Epitrix cucumeris* Harris)

The potato flea-beetle is about 1/16 inch in length and nearly black in color. The adults hibernate under trash and appear in early spring to feed on a great variety of plants before the potatoes come up. The beetles migrate to potato fields in great numbers as soon as the plants appear aboveground. In feeding, the beetle makes an opening in the epidermis of the leaf and then eats out the pulp, but leaves the epidermis on the opposite side of the leaf intact. Later this bit of epidermis dries out and may break away, leaving a small hole through the leaf. In this way the leaves are often riddled with holes and some of them are killed.

After feeding on the leaves for some time the beetles enter the soil to deposit their eggs near the roots. The larvae feed on the underground parts of the plant and often tunnel just under the surface of the tuber. Thus long sinuous channels are formed by this rupturing of the skin of the potato. Sometimes they burrow deeper into the flesh of the tuber, producing a corky sliver which may become infected with disease organisms. The larvae pupate in the soil, and the beetles of the new brood become abundant in late July or early August. These beetles are much more numerous than those of the spring brood but the plants are larger and more able to withstand attack. Nevertheless, they may cause significant injury to the foliage.

The injury caused by flea-beetles may be prevented to a considerable degree by keeping the plants well covered with bordeaux mixture during the period when the beetles are most numerous. This is especially important when the plants first come up and are being attacked by the overwintered beetles. Calcium arsenate is usually applied in the first or in the first

and second sprays for the control of the Colorado potato beetle and undoubtedly aids in protecting the plants from flea-beetle attack. The feeding habits of the flea-beetles are such as to enable a large proportion of them to escape the poison. It is therefore a question whether it pays to use the poison in July when the summer brood of flea-beetles make their appearance. It is not the usual practice to use the poison at that time but to rely on the deterrent action of the bordeaux mixture.

Potato leaf-hopper

(*Empoasca fabae* Harris)

The potato leaf-hopper is a small, slender, green or yellowish insect about 1/10 inch in length, found mostly on the underside of the leaves. When disturbed they spring quickly into the air, make a short flight, and disappear under the leaves of another plant. The young hoppers, or nymphs, are pale greenish in color and resemble the adult in general appearance, but lack wings. When disturbed they move with a peculiar sideling motion.

The injury caused by the leaf-hopper to potatoes is known as *hopper-burn*. The injury first appears as a slight yellowing of the tip of the leaf. The edge of the leaf then turns brown, curls upward, and dries out, becoming brittle The injury spreads from the margin towards the center of the leaf, thus leaving the base and an area along the midrib green after the edge has been killed. In severe cases the foliage is destroyed and the plants are killed. In some seasons the loss caused by the leaf-hopper is greater than that inflicted by all other insects and diseases attacking the potato.

The adult leaf-hoppers hibernate under trash and emerge early in the spring. They feed for a time on a great variety of weeds and cultivated plants. Common dock is a favorite spring food plant. Early beans also attract large number of the insects. Usually the hoppers do not migrate to potatoes in any great numbers till the latter part of July. The adults are to be found on the underside of the leaves where they deposit their minute greenish eggs in the larger veins and in the leaf stems. The eggs hatch in a week to ten days and the young pale greenish nymphs appear on the underside of the leaves. The nymphs pass through five stages and acquire wings at the fifth molt. In the last stage the nymph is about 1/10 inch in length; the head and the thorax are pale green and the abdomen is yellow. In warm weather the nymphs reach maturity in about two weeks, but towards the end of the season when it is cooler three weeks are required. Two full generations and a partial third and fourth brood usually develop each season. As the adults deposit eggs over a period of two months or more the different generations greatly overlap so that in August the adults of three broods may be ovipositing at the same time. This is the period

when the insects reach their greatest abundance on the potatoes and when hopper-burn injury develops most rapidly. Breeding continues on potatoes till the plants are killed by blight or frost and the surviving adults are driven to other plants or go into hibernation.

Control

Thorough and careful spraying with bordeaux mixture at intervals of about ten days is the most effective means of controlling the potato leaf-hopper. Both the adults and nymphs die within a day or two when feeding on leaves well covered with bordeaux. They are sucking insects and feed exclusively on the plant juices which they extract from the leaf by means of the needle-like bristles of their mouthparts. It is believed that they are killed by the copper in the leaves derived from the covering of bordeaux mixture. At any rate, regular and careful spraying with this material is an effective and practical method of keeping the hoppers under control and will materially increase the size and quality of the crop. Dusting with copper-lime dust gives slightly less control of leaf-hoppers than does spraying with bordeaux mixture.

Tarnished plant bug

(*Lygus pratensis* Linnaeus)

The growing tips of potato vines often wilt, droop, and turn gray. This injury is caused by the punctures of a very active, brownish plant-bug, about ¼ inch in length. These bugs breed on a great variety of wild and cultivated plants. The great migration of the insects into potato fields takes place when hay is cut and the weeds on which they are feeding are destroyed. It is at this time that the wilted tips become noticeable in the potato fields. No practicable method of preventing this injury to potatoes has been discovered.

Potato aphis

(*Macrosiphum solanifolii* Ashmead)

In up-state New York the direct loss from aphid injury to potatoes is usually not serious, and it would rarely pay to spray or dust for their control. On Long Island and in some of the Southern States it is sometimes necessary to make special applications of a nicotine and soap spray or of nicotine dusts to protect the crop. These applications are rather expensive and should be made only in emergencies. It is true that aphids are largely responsible for the spread of virus diseases, but this problem is best solved by other methods than by attempting to keep the plants free of aphids.

Potatoes and Camels

THE homely spud, and the ungainly camel, it is said, exemplify better than any other objects the truth of the old adage, "handsome is as handsome does."

The potato is an earthen-like mass, with no claims to beauty in form and color; yet it has become a basic and tasteful food wherever it is grown. The camel stands for all that is ungraceful among the beasts that serve man, but he serves efficiently wherever he can live—and he can subsist and exist in some pretty tough places.

Potatoes do best, other things being equal, where they are given most care and attention.

If you want to know more about the culture and care of potatoes, perhaps the following pamphlets will interest you.

Better seed for commercial vegetable growers (E 122) *Work*

Potato diseases and their control (E 135) *Barrus and Chupp*

Commercial varieties of vegetable for New York State (E 176) *Schneck*

The control of diseases and insects affecting vegetable crops (E 206) *Crosby and Chupp*

They are free for the asking and can be obtained from

The Office of Publication
New York State College of Agriculture
Ithaca, New York

This bulletin is published and distributed in furtherance of the purposes provided for in the Act of Congress of May 8, 1914